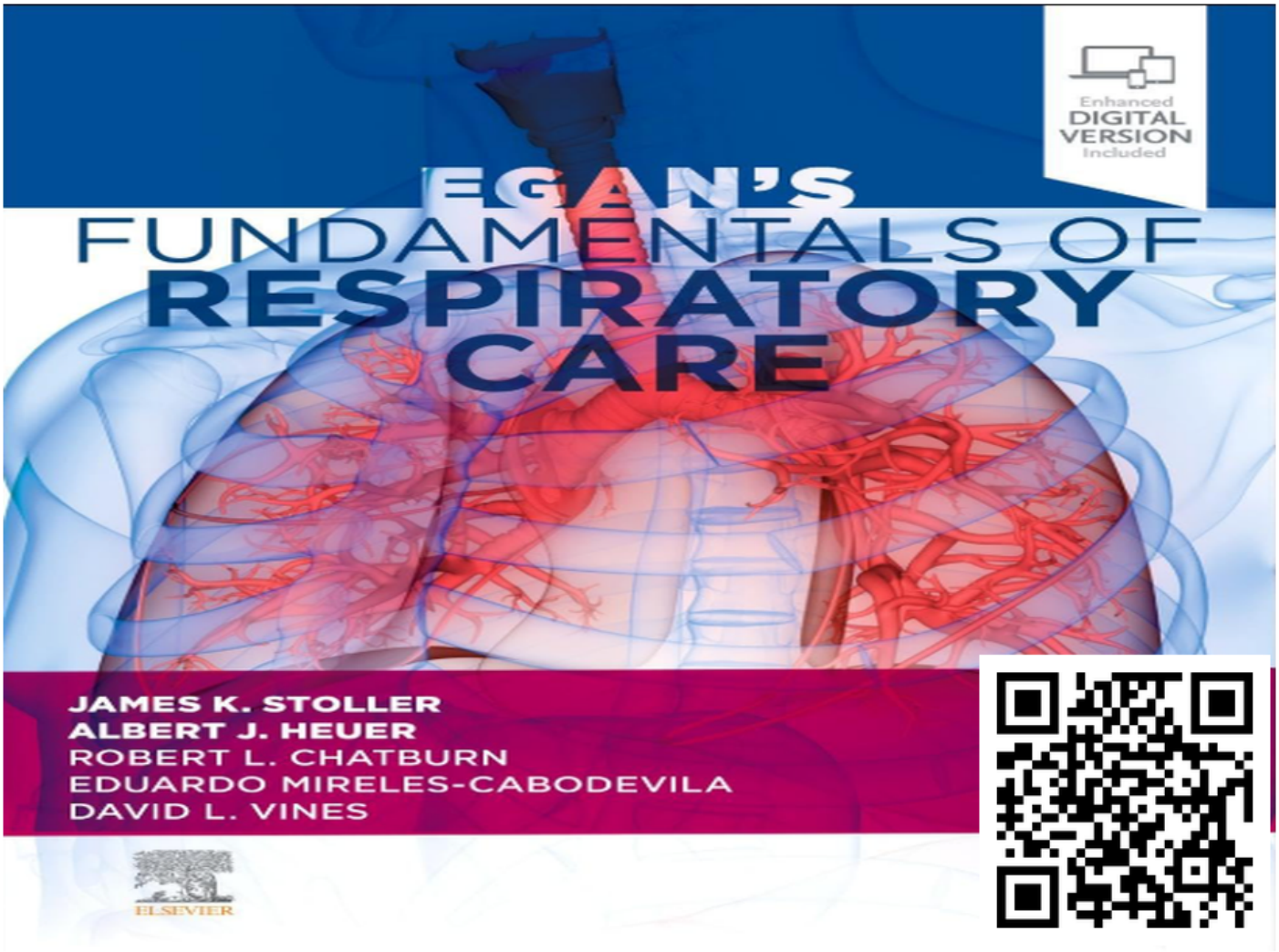

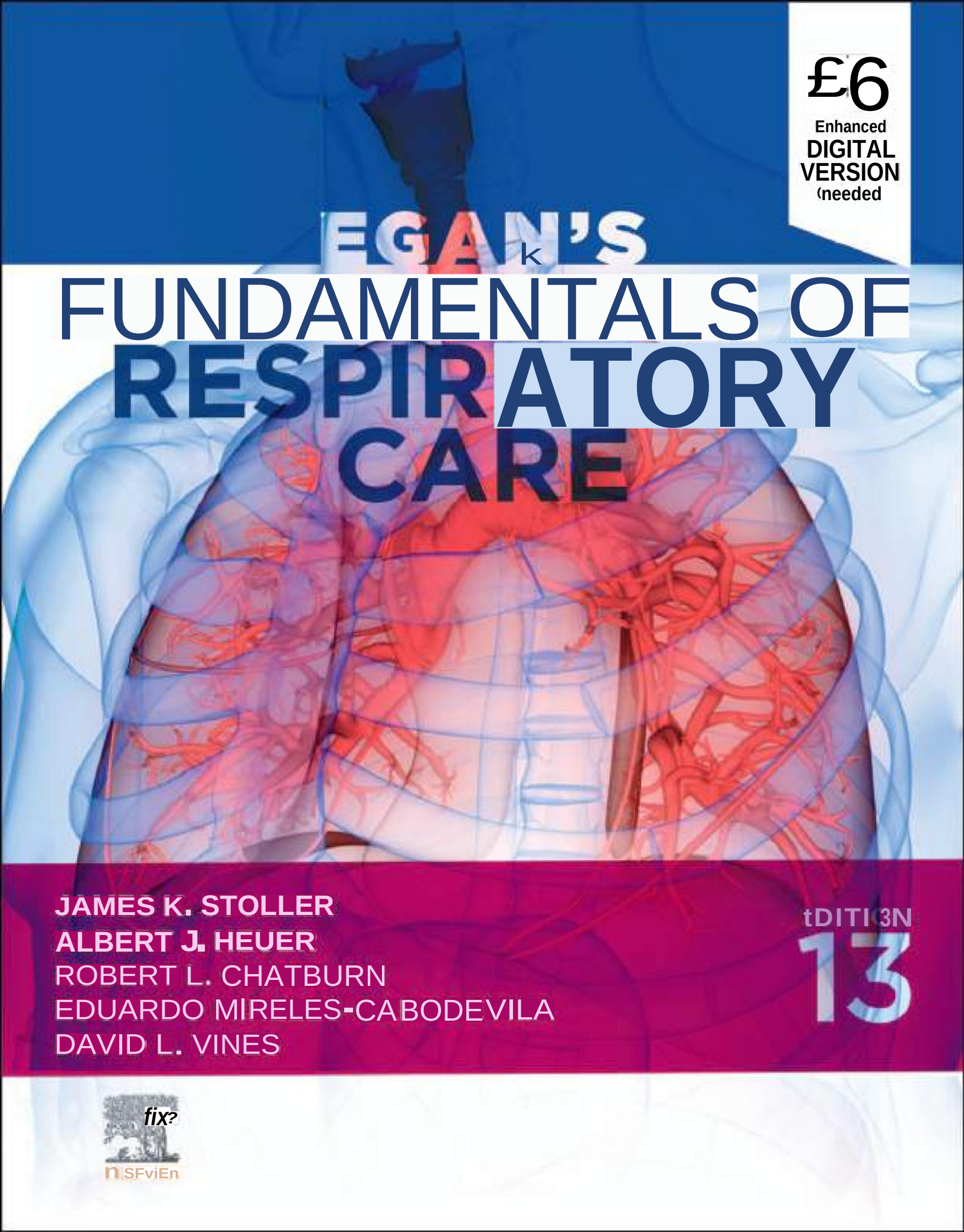
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EGAN'S
FUNDAMENTALS OF
RESPIRATORY
CARE
JAMES K. STOLLER
ALBERT J. HEUER
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We want to acknowledge and dedicate the book to the memory of Bob Kacmarek, PhD, RRT, FAARC. Bob served as a co-editor of the 9th through 12th editions of *Egan's Fundamentals of Respiratory Care* and is indisputably a legend in respiratory care. His wisdom and unique ability to synthesize complex information is amply reflected in prior editions of *Egan's* and carries over into the current 13th edition. To acknowledge this, even though Bob's untimely passing predated writing the current edition, his seminal contributions to multiple chapters will continue to be recognized by including his name as a co-author on chapters to which he materially contributed in the prior 12th edition.

Bob's contributions to respiratory care are countless and immeasurably impactful, perhaps singularly so in a field replete with brilliant contributions over decades. He is only one of four individuals ever to be invited to deliver both the Philip Kittredge Memorial Lecture in 1991 (when it was called the Program Committee Lecture) and, befitting his commitment to this book over many years, the Donald F. Egan Memorial Lecture in 2010. He was also one of only 44 people to receive the AARC's highest award, the Jimmy A. Young medal, in 2008. Bob's native inquisitiveness and rigor spawned multiple insights that affect everyday respiratory care practice, especially regarding mechanical ventilation. Going beyond his amazing intellectual and pedagogic gifts, Bob was a dear friend and someone who made you better by knowing him.

Jamie Stoller first met Bob during his critical care training at the Massachusetts General Hospital, when Bob was relatively newly minted as the director of respiratory care. That friendship prompted many collaborations and other books (e.g., *Monitoring in Respiratory Care,* published in 1993). Beyond any academic collaborations, Bob's friendship and mentorship spurred Jamie's early passion for respiratory care, which certainly contributed to his being invited to serve as a co-editor of *Egan's* starting with the 7th edition.

Bob's footprint in respiratory care was immense and naturally attracted the talent of those keen to collaborate with such a luminary.

Al Heuer has been a long-time chapter contributor for *Egan's* but was invited to join as a co-editor beginning with the 10th edition. Since then, Al co-authored a peer-reviewed manuscript with Bob and worked with him mentoring graduate students mainly on projects related to mechanical ventilation. Bob has been one of the most dominant, positive influence on Al's development as a respiratory care educator and scholar.

Eduardo Mireles-Cabodevila, who newly joins as a co-editor on this 13th edition, collaborated with Bob in co-authoring research on APRV for ARDS. Rob Chatburn collaborated with Bob on the editorial board for the *Respiratory Care* journal and has authored many chapters in books that Bob edited; like the others, he has been a longtime friend and colleague spanning four decades. David Vines contributed book chapters that he also edited, but Bob's shared wisdom, advice, and intellectual discussions have left an indelible impression.

Bob's untimely passing has left a huge void in the field of respiratory care and our hearts. His work lives on in these pages, which carry forward his mission of educating respiratory therapists to offer superb care in an evidence-based manner. We miss and salute you, our friend, and take solace in knowing that you live on in this work and its influence on the lives of many caregivers and patients alike.

My deepest gratitude goes to my wife, Terry, for her tireless love and support that is the bedrock upon which my work has always happened, and to the rest of my family—my son, Jake, daughter-in-law, Abigail, and grandson, Willy—who are the why. I offer deep thanks to my able and loyal assistant, Maria Hernandez, who has organized and bound the collaboration that has made this book possible. Finally, I dedicate this work to the thousands of respiratory care providers who bring the knowledge herein to the bedside in service of so many patients' care and well-being.

JKS

I dedicate my work on this textbook to my wife, Laurel, as well as my family and close friends who I love deeply and who make me feel loved despite my periodic absences while working on such projects; to the Egan's editorial team—Jamie, David, Rob, and Eduardo—who are giants in the profession of respiratory care and with whom I am both humbled and privileged to work; and to my faculty and clinical colleagues, who provide me with much of the inspiration to strive for excellence in teaching, scholarship, and patient care.

AJH

I offer my most profound gratitude to my daughters, Maya and Kendra, whose unfaltering love and support have helped me sustain the effort required to succeed professionally. I dedicate my portion of this work to all those who have the wisdom to be what they want to see.

RLC

To Marina, my sunlight. To Montse, Santi, and Ramon, a constant source of love, joy, and pride. To Mario, an amazing physician who taught me that persistence and creativity always deliver. To Cristi, whose never-ending energy and passion for helping anyone make this world better. To Rob and Jamie for being kind critics, endless collaborators, and virtuous mentors. Finally, to all the healthcare workers who work to keep or make us healthy.

EMC

To my beautiful wife, Edita, your love and support are appreciated beyond what words can say and make everything possible. To my children, Adele, Isabella, and Jackson, your love and insights keep me grounded. I am eternally grateful to my colleagues who provide collaboration and drive to achieve more. Finally, to the other *Egan's* editors and contributors, your shared knowledge and expertise are humbling and inspiring.

DLV

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PREFACE

Donald F. Egan, MD, the original author of *Egan's Fundamentals of Respiratory Care,* sought to provide a foundation of knowledge for respiratory therapy students learning the practice in 1969. However, the scope of the respiratory care profession is ever-expanding, and the skills and information needed to be an effective respiratory therapist have grown with it. With improved technology as well as vast scientific and medical advances, the body of knowledge required for respiratory therapists has increased greatly since the first edition of the text was published.

Now in its thirteenth edition, *Egan's Fundamentals of Respiratory Care* encompasses the most relevant information to date and has provided a comprehensive knowledge base for students and professionals for more than 50 years. While these updated editions of *Egan's Fundamentals of Respiratory Care* still accomplish Dr. Egan's original goal—"to present what is felt to be the minimum knowledge for the safe and effective administration of inhalation therapy"—this text also goes far beyond the minimum requisite knowledge, developing important concepts and providing detailed information and resources to enhance student comprehension.

Every editor and contributor to the book is a leading figure in respiratory care, and the vast experience of these individuals ensures that critical content is covered accurately. Using the combined knowledge of these individuals and the book's many authoritative contributors, *Egan's Fundamentals of Respiratory Care* covers the role of respiratory therapists, the scientific bases for treatment, and clinical application skills. With 58 detailed chapters, each focused on a unique aspect of respiratory care, *Egan's Fundamentals of Respiratory Care* is without equal in providing the prerequisite information required of a respiratory therapist today.

ORGANIZATION

This edition of the text is organized in a logical sequence of sections and chapters that build on each other to facilitate comprehension of the material. The earlier sections provide a basis for the profession and cover the physical, anatomic, and physiologic principles necessary to understand succeeding chapters. The middle portion of the textbook addresses specific cardiopulmonary diseases and conditions, followed by chapters that detail diagnostic and therapeutic techniques deemed essential for the practice of state-of-the-art respiratory care. Key information on patient and family education, disease prevention and management, and alternate sites of care, as well as ethics and end-of-life, are also provided in the later chapters. In order of presentation, the seven sections are:

I. Foundations of Respiratory Care
II. Applied Anatomy and Physiology
III. Assessment of Respiratory Disorders
IV. Review of Cardiopulmonary Disease
V. Basic Therapeutics
VI. Acute and Critical Care
VII. Patient Education and Long-Term Care

FEATURES

The book has many characteristic features designed with the student in mind, making *Egan's Fundamentals of Respiratory Care* unique and engaging as a primary textbook. Each chapter begins in a similar manner, outlining the content and drawing attention to what should be mastered through the use of:

- Chapter Objectives
- Chapter Outlines
- Key Terms

The most important features within each chapter are accented by the ample use of figures, boxes, and tables containing key information and by the use of:

- "Rules of Thumb"—"pearls" of information highlighting rules, formulas, and key points necessary to the study of respiratory therapy and to future clinical practice
- "Mini-Clinis"—critical thinking case studies illustrating potential problems that may be encountered during patient care
- Therapist-Driven Protocols—examples of decision trees developed by hospitals and used by respiratory therapists to assess patients, initiate care, and evaluate outcomes

Also, each chapter concludes with:

- A "Summary Checklist" of key points that the student should have mastered on completion of the chapter (eBook version)
- A list of the most relevant references

NEW TO THIS EDITION

- Returning as textbook co-editor is world-renowned James K. Stoller, MD, MS, of the Cleveland Clinic, who has co-edited six editions of this textbook and is credited with the tradition of quality associated with this textbook. Also returning as co-editor is Albert Heuer, RRT, PhD, of Rutgers University and a long-time respiratory care educator and scholar, who has worked closely with Dr. Stoller over several editions to ensure the success of the *Egan's* textbook. In addition, long-standing contributors from the Cleveland Clinic, now joining the *Egan's* editorial team as co-editors, are Robert L. Chatburn, RRT, MS, a pioneer in respiratory care simulations and education, and Eduardo Mireles-Cabodevila, MD, a consummate clinician educator and Director of the Medical Intensive Care Unit and Simulation Center at the Cleveland Clinic. Also elevated to co-editor is David L. Vines, RRT, PhD, of Rush University Medical Center and long-time

respiratory care educator and clinician, as well as a board member and former National Board for Respiratory Care (NBRC) president. This editorial team is one of the strongest in *Egan's* history, and the readers will benefit from their ability to recruit talented contributors and assemble a well-researched, comprehensive, and clearly written textbook, still regarded as the single best source in respiratory care education.
- This edition has been updated to reflect the most current information in the National Board for Respiratory Care (NBRC) Therapist Exam Content Outline. Also featured is an expanded role for the NBRC Exam Matrix Correlation chart within all student and instructor offerings.
- Many chapters, including those related to disease management, airway pharmacology, emergency life support, invasive and noninvasive mechanical ventilation, and extracorporeal life support, have been substantially revised or completely rewritten to reflect the dynamic and expanding field of respiratory care.
- The content of the entire text has been refined and simplified to be more easily understood and relevant to our key audiences: respiratory therapy students, faculty, and therapists worldwide.

LEARNING AIDS

Workbook and Evolve Resources

In addition to the previously described digital resources associated with each chapter in this textbook, The *Workbook for Egan's Fundamentals of Respiratory Care* is another exceptional resource for students. Offering a wide range of activities, it allows students to apply the knowledge they have gained using the core text. Presented in an engaging format, the workbook breaks down difficult concepts and guides students through the most important information. Beyond the many NBRC-style multiple-choice questions in the workbook, students can access animations, an English/Spanish glossary, student lecture notes, Chapter Summary Checklists, and Body Spectrum, an anatomy coloring book.

Answers to the *Workbook* are available on the Evolve site. Evolve also includes animations, English/Spanish Glossary, Student Lecture Notes, and Body Spectrum Anatomy Coloring Book.

FOR THE INSTRUCTOR

Evolve Resources

Evolve is an interactive learning environment designed to work in coordination with this text. Instructors may use Evolve to provide an Internet-based course component that expands the concepts presented in class. Evolve can be used to publish the class syllabus, outlines, and lecture notes; set up "virtual office hours" and email communication; and encourage student participation through chatrooms and discussion boards. Evolve also allows instructors to post exams and manage their grade books.

The intuitive and comprehensive Evolve Learning Resources associated with this text provide instructors with valuable resources to use as they teach, including:
- More than 3000 test bank questions available in ExamView
- Comprehensive PowerPoint presentations for each chapter
- An image collection of the figures in the book
- Workbook answer key
- TMC/CSE Correlation Guide
- A compilation of the digital resources associated with each chapter

For more information, visit http://evolve.elsevier.com/Egans or contact an Elsevier sales representative.

CONTENTS

SECTION I Foundations of Respiratory Care

SECTION II Applied Anatomy and Physiology

SECTION VI Acute and Critical Care

VIDEO CONTENTS

1

Early History of Respiratory Care[a]

James K. Stoller and Albert J. Heuer

OUTLINE

CHAPTER OBJECTIVES

After reading this chapter you will be able to:

- Define respiratory care
- Summarize some of the major events in the history of science and medicine that have directly affected respiratory care
- Explain how the respiratory care profession began
- Describe the historical development of the major clinical areas of respiratory care
- Name some of the important historical figures in respiratory care
- Describe the major respiratory care educational, credentialing, and professional associations
- Explain how the important respiratory care organizations began
- Describe the development of respiratory care education

KEY TERMS

American Association for Respiratory Care (AARC)
American Respiratory Care Foundation (ARCF)
Board of Medical Advisors (BOMA)
Committee on Accreditation for Respiratory Care (CoARC)
Fellow of the American Association for Respiratory Care (FAARC)
International Council for Respiratory Care (ICRC)
National Board for Respiratory Care (NBRC)
physician assistant
respiratory care
respiratory care practitioner
respiratory therapist (RT)
respiratory therapy

[a]Thanks to Robert M. Kacmarek for contributions to earlier versions of this chapter.

The history of science and medicine is a fascinating topic, which begins in ancient times and progresses to the 21st century. Although respiratory care is a newer discipline, its roots go back to the dawn of civilization. The first written account of positive-pressure ventilation using mouth-to-mouth resuscitation is thought to have been recorded more than 28 centuries ago.[1] Air was thought to be one of the four basic elements by the ancients, and the practice of medicine dates back to ancient Babylonia and Egypt. The progression of science and medicine continued through the centuries, and the development of the modern disciplines of anesthesiology, pulmonary medicine, and respiratory care during the 20th and centuries depended on the work of many earlier scientists and physicians. This chapter describes the early development of respiratory medicine and the history and development of the field of respiratory care. Specifically, after an historical overview, the birth of respiratory care as a profession is discussed, followed by a discussion of specific therapies (e.g., supplemental oxygen, mechanical ventilation) and a description of various respiratory care organizations (e.g., the American Association for Respiratory Care [AARC], the American Respiratory Care Foundation [ARCF]).

DEFINITIONS

Respiratory care, also known as **respiratory therapy**, has been defined as the health care discipline that specializes in the promotion of optimal cardiopulmonary function and health.[2] **Respiratory therapists (RTs)** apply scientific principles to prevent, identify, and treat acute or chronic dysfunction of the cardiopulmonary system.[2] Respiratory care includes the assessment, treatment, management, control, diagnostic evaluation, education, and care of patients with deficiencies and abnormalities of the cardiopulmonary system.[2] Respiratory care is increasingly involved in preventing respiratory disease, managing patients with chronic respiratory disease, and promoting health and wellness.[2]

RTs, also known as **respiratory care practitioners**, are health care professionals who are educated and trained to provide respiratory care to patients. Approximately 75% of all RTs work in hospitals or other acute care settings.[3] However, many RTs are employed in clinics, physicians' offices, skilled nursing facilities, and cardiopulmonary diagnostic laboratories. Others work in research, disease management programs, home care, and industry. RTs are also employed by colleges and universities to teach in RT training programs.

The Bureau of Labor Statistics reports that there are 135,600 RTs in the United States as of 2021 and that the number of RTs is expected to grow by 14% from 2021 to 2031.[3] As the incidence of chronic respiratory diseases continues to increase, the demand for RTs is expected to be even greater in the years ahead. Although the RT as a distinct health care provider was originally unique to North America, since the 1990s, there has been a steady increase in specially trained professionals providing respiratory care worldwide. This trend is referred to as the *globalization of respiratory care.*

RULE OF THUMB Respiratory care has been defined as the health care discipline that specializes in promoting optimal cardiopulmonary function and health.[2] RTs apply scientific principles to prevent, identify, and treat acute or chronic dysfunction of the cardiopulmonary system.

HISTORY OF RESPIRATORY MEDICINE AND SCIENCE

Several excellent reviews of the history of respiratory care have been written.[1,4–6] Table 1.1 summarizes notable historical events in respiratory care and a brief description of the history of science and medicine follows.

Ancient Times

Humans have been concerned about the common problems of sickness, disease, old age, and death since primitive times. Early cultures developed herbal treatments for many diseases, and surgery may have been performed in Neolithic times. Physicians practiced medicine in ancient Mesopotamia, Egypt, India, and China.[1,4,7] However, the foundation of modern Western medicine was laid in ancient Greece, with the development of the Hippocratic corpus.[1,4,7,8] This ancient collection of medical treatises is attributed to the "father of medicine," Hippocrates, a Greek physician who lived during the fifth and fourth centuries BC.[1,7,8] Hippocratic medicine was based on four essential fluids, or "humors"—phlegm, blood, yellow bile, and black bile—and the four elements—earth (cold, dry), fire (hot, dry), water (cold, moist), and air (hot, moist). Diseases were thought to be humoral disorders caused by imbalances in these essential substances. Hippocrates believed that an essential substance in the air was distributed to the body by the heart.[1] The Hippocratic oath, which instructs physicians to follow certain ethical principles, is taken in a modern form by medical students at graduation.[1,8]

Aristotle (384 to 322 BC), a Greek philosopher and perhaps the first great biologist, believed that knowledge could be gained through careful observation.[1,8] He made many scientific observations, including some obtained by performing experiments on animals. Erasistratus (~330 to 240 BC), regarded by some as the founder of the science of physiology, developed a pneumatic theory of respiration in Alexandria, Egypt, in which air *(pneuma)* entered the lungs and was transferred to the heart.[1,7] Galen (AD 130 to 199) was an anatomist in Asia Minor whose comprehensive work dominated medical thinking for centuries.[1,6,7] Galen also believed that inspired air contained a vital substance that somehow charged the blood through the heart.[1]

The Middle Ages, Renaissance, and Enlightenment Period

The Romans carried on the Greek traditions in philosophy, science, and medicine. With the fall of the Western Roman Empire in AD 476, many Greek and Roman texts were lost and Europe entered a period during which few advances were made in science or medicine. In the seventh century AD, the Arabians conquered Persia, where they found and preserved many of the

TABLE 1.1 Major Historical Events in Respiratory Care in the Twentieth to Twenty First Centuries

1909	Melltzer (1851—1920; United States) introduces oral endotracheal intubation.
1910	Oxygen tents are in use, and the clinical use of aerosolized epinephrine is introduced.
1911	Drager (1847—1917; Germany) develops the Pulmotor ventilator for use in resuscitation.
1913	Jackson develops a laryngoscope to insert endotracheal tubes.
1918	Oxygen mask is used to treat combat-induced pulmonary edema.
1926	Barach develops an oxygen tent with cooling and carbon dioxide removal.
1928	Drinker develops his "iron lung" negative-pressure ventilator.
1938	Barach develops the meter mask for administering dilute oxygen. Boothby, Lovelace, and Bulbulian devise the BLB mask at the Mayo Clinic for delivering high concentrations of oxygen.
1945	Motley, Cournand, and Werko use intermittent positive-pressure ventilation to treat various respiratory disorders.
1947	The Inhalation Therapy Association (ITA) is formed in Chicago, Illinois. The ITA later becomes the AARC.
1948	Bennett introduces the TV-2P positive-pressure ventilator.
1952	Mørch introduces the piston ventilator.
1954	The ITA becomes the AAIT.
1954	The American Association for Inhalation Therapists (AAIT) is formed.
1956	The first guidelines for respiratory care educational programs are published.
1958	Bird introduces the Bird Mark 7 positive-pressure ventilator.
1960	The Campbell Ventimask for delivering dilute concentrations of oxygen is introduced.
1961	Jenn becomes the first registered respiratory therapist. Also, metaproterenol, a preferential β-2 bronchodilator, is introduced.
1963	The Board of Schools is formed to accredit inhalation therapy educational programs.
1964	The Emerson Postoperative Ventilator (3-PV) positive-pressure volume ventilator is introduced.
1967	The Bennett MA-1 volume ventilator is introduced, ushering in the modern age of mechanical ventilatory support for routine use in critical care units.
1967	The combined pH-Clark-Severinghaus electrode is developed for rapid blood gas analysis.
1968	The fiberoptic bronchoscope becomes available for clinical use. The Engström 300 and Ohio 560 positive-pressure volume ventilators are introduced.
1969	ARDS and PEEP are described by Petty, Ashbaugh, and Bigelow.
1970	The Swan-Ganz catheter, developed for the measurement of pulmonary artery pressures, is introduced. The American Respiratory Care Foundation (ARCF) is incorporated. The JRCITE is incorporated to accredit respiratory therapy educational programs.
1970	Joint Review Committee for Inhalation Therapy Education (JRCITE/JRCRTE) is formed.
1971	CPAP is introduced by Gregory. The *Respiratory Care* journal is introduced.
1972	The Siemens Servo 900 ventilator is introduced.
1973	IMV is described by Kirby and Downs. The AAIT becomes the AART.
1973	The AAIT is renamed as the American Association for Respiratory Therapy (ARRT)
1974	The IMV Emerson ventilator is introduced.
1974	The National Board for Respiratory Therapy (NBRT) is formed.
1975	The Bourns Bear I ventilator is introduced.
1977	The JRCITE becomes the JRCRTE.
1978	Puritan Bennett introduces the MA-2 volume ventilator. The *AARC Times* magazine is introduced.
1979	AIDS is recognized by the Centers for Disease Control (CDC [later, Centers for Disease Control and Prevention]).
1982	Siemens Servo 900C and Bourns Bear II ventilators are introduced.
1982	The ARRT becomes the AARC.
1983	The NBRT becomes the National Board for Respiratory Care (NBRC).
1983	President Reagan signs a proclamation declaring National Respiratory Care Week.
1984	Bennett 7200 microprocessor-controlled ventilator is introduced.
1984	The AART is renamed the AARC.
1984	The NBRC begins offering its first specialty examinations, starting pulmonary function technology (CPFT/RPFT).
1991	The Servo 300 ventilator is introduced.
1992, 1993	The AARC holds national respiratory care education consensus conferences.
1994	The CDC publishes the first guidelines for the prevention of ventilator-associated pneumonia.
1996	The CoARC is formed, replacing the JRCRTE.
1990's—2010's	A host of new or modified modes of mechanical ventilation are introduced, including pressure-regulated volume control (PRVC), neutrally adjusted ventilatory assist (NAVA), airway pressure release ventilation (APRV).

AAIT, American Association for Inhalation Therapist; *AARC*, American Association for Respiratory Care; *ARDS*, acute respiratory distress syndrome; *BLB*, Boothby, Lovelace, and Bulbulian; *CoARC*, Committee on Accreditation for Respiratory Care; *CPAP*, continuous positive-airway pressure; *IMV*, intermittent mandatory ventilation; *JRCITE*, Joint Review Committee for Inhalation Therapy Education; *JRCRTE*, Joint Review Committee for Respiratory Therapy Education; *NBRC*, National Board for Respiratory Care; *NBRT*, National Board for Respiratory Therapy; *PEEP*, positive end-expiratory pressure.

Data from references 1, 3–9, 11–14, and 17.

works of the ancient Greeks, including the works of Hippocrates, Aristotle, and Galen.[1,7] A golden age of Arabian medicine (AD 850 to 1050) followed.

An intellectual rebirth in Europe began in the 12th century.[1,7] Medieval universities were formed, and contact with the Arabs in Spain and Sicily reintroduced ancient Greek and Roman texts. Magnus (1192 to 1280) studied the works of Aristotle and made many observations related to astronomy, botany, chemistry, zoology, and physiology. The Renaissance (1450 to 1600) ushered in a period of scientific, artistic, and medical advances. Leonardo da Vinci (1452 to 1519) studied human anatomy, determined that subatmospheric intrapleural pressures inflated the lungs, and observed that fire consumed a vital substance in the air without which animals could not live.[1,4] Vesalius (1514 to 1564), considered to be the founder of the modern field of human anatomy, performed human dissections and experimented with resuscitation.[1] In 1543, the date commonly given as the birth of modern science, Copernicus observed that the planet Earth orbited the sun,[8] challenging the earlier belief that the Earth was the center of the universe.

The 17th century was a time of great advances in science. Accomplished scientists from this period include Kepler, Bacon, Galileo, Pascal, Hooke, and Newton. In 1628, Harvey fully described the circulatory system.[4,8] In 1662, the chemist Boyle published what is now known as Boyle's law, governing the relationship between the volume and pressure of a gas,[8] that is, that for a given mass at a constant temperature, the product of the pressure and volume of a gas is constant. Torricelli invented the barometer in 1650, and Pascal showed that atmospheric pressure decreases with altitude.[1,4] van Leeuwenhoek (1632 to 1723), known as the "father of microbiology," improved the microscope and was the first to observe and describe single-celled organisms, which he called "animalcules."[7]

The 18th-century Enlightenment period brought further advances in the sciences. In 1754, Black described the properties of carbon dioxide, although the discovery of carbon dioxide should be credited to van Helmont, whose work occurred approximately 100 years earlier.[1] In 1774, Priestley described oxygen, which he called "dephlogisticated air."[1,4] Before 1773, Scheele performed the laboratory synthesis of oxygen, which he called "fire air"; a general description of his discovery appeared in 1774, and a more thorough description in 1777.[1,4] Shortly after the discovery of oxygen, Spallanzani worked out the relationship between the consumption of oxygen and tissue respiration.[1] In 1787, Charles described the relationship between gas temperature and volume, now known as Charles' law.[8] In experiments performed between 1775 and 1794, Lavoisier showed that oxygen was absorbed by the lungs and that carbon dioxide and water were exhaled.[1,4] In 1798, Beddoes began using oxygen to treat various conditions at his Pneumatic Institute in Bristol, England.[1,4]

RULE OF THUMB In 1662, the chemist Boyle published what is now known as Boyle's law, governing the relationship between gas volume and pressure. Boyle's law states that for a given mass at a constant temperature, the product of the pressure and volume of a gas is constant.

Nineteenth and Early Twentieth Centuries

During the 19th century, important advances were made in physics and chemistry related to respiratory physiology. Dalton described his law of partial pressures for a gas mixture (i.e., Dalton's law that the total pressure of a mixture of gases is equal to the sum of the partial pressures of the component gases) in 1801 and his atomic theory in 1808.[8] Young in 1805 and de LaPlace in 1806 described the relationship between pressure and surface tension in fluid droplets.[8] Gay-Lussac described the relationship between gas pressure and temperature in 1808; in 1811, Avogadro determined that equal volumes of gases at the same temperature and pressure contain the same number of molecules.[1,8] In 1831, Graham described his law of diffusion for gases (Graham's law, i.e., that the rate of diffusion of a gas is inversely proportional to the square root of its molecular weight).[8]

In 1865, Pasteur advanced his "germ theory" of disease, which held that many diseases are caused by microorganisms.[8] Medical advances during this time included the invention of the spirometer and ether anesthesia in 1846, antiseptic techniques in 1865, and vaccines in the 1880s.[1,4,7] Koch, a pioneer in bacteriology, discovered the tubercle bacillus, which causes tuberculosis, in 1882, and the vibrio bacterium, which causes cholera, in 1883.[7] He also developed Koch's postulates, which are criteria designed to establish a causative relationship between a microbe and a disease. The four Koch's postulates are:

1. The bacteria must be present in every case of the disease.
2. The bacteria must be isolated from the host with the disease and grown in pure culture.
3. The specific disease must be reproduced when a pure culture of the bacteria is inoculated into a healthy susceptible host, and
4. The bacteria must be recoverable from the experimentally infected host.

Respiratory physiology also progressed with the measurement in 1837 of blood oxygen and carbon dioxide content, description around 1880 of the respiratory quotient (i.e., a dimensionless number that is the ratio of the volume of carbon dioxide released over the volume of oxygen absorbed during respiration), demonstration in 1885 that carbon dioxide is the major stimulant for breathing, and demonstration in 1878 that oxygen partial pressure and blood oxygen content were related.[1,4,9] In 1895, Roentgen discovered the x-ray, and the modern field of radiologic imaging sciences was born.[8] Pioneering respiratory physiologists of the early 20th century described oxygen diffusion, oxygen and carbon dioxide transport, the oxyhemoglobin dissociation curve, acid-base balance, and the mechanics of breathing and made other important advances in respiratory physiology.

RULE OF THUMB In experiments performed between 1775 and 1794, Lavoisier showed that oxygen was absorbed by the lungs and that carbon dioxide and water were exhaled.

DEVELOPMENT OF THE RESPIRATORY CARE PROFESSION

Clinical Advances in Respiratory Care

The evolution of the respiratory care profession depended in many ways on developments in the various treatment techniques that matured in the 20th century. As the scientific basis for oxygen therapy, mechanical ventilatory support, and administration of medical aerosols became well established, the need for a health care practitioner to provide these services became apparent. Concurrent with this need was the continuing development of specialized cardiopulmonary diagnostic tests and monitoring procedures, which also required skilled health care specialists to perform.

The first health care specialists in the field were oxygen technicians in the 1940s.[1,4,5] The development of positive-pressure breathing during World War II for breathing support of high-altitude pilots led to its use as a method to treat pulmonary patients and deliver aerosol medications during the 1950s, expanding the role of the oxygen technicians. Inhalation therapists began to be trained in the 1950s, and formal education programs began in the 1960s.[1,4,5] By the end of the 1960s, respiratory care personnel were all referred to as "inhalation therapists"; they provided oxygen therapy from large H cylinders (see Chapters 41 and 42) and oxygen tents, masks, and nasal catheters. In addition, these inhalation therapists delivered aerosolized medications and performed intermittent positive-pressure breathing (IPPB) treatments. The development of sophisticated mechanical ventilators in the 1960s and beyond naturally led to a further expansion of the role of RTs, who soon also found themselves responsible for arterial blood gas and pulmonary function laboratories. In 1974, the designation *respiratory therapist* became standard, and the RT became the allied health professional primarily concerned with the assessment, diagnostic testing, treatment, education, and care of patients with deficiencies and abnormalities of the cardiopulmonary system.

RULE OF THUMB When information about the respiratory care profession is being sought, the best place to look is the AARC (see www.AARC.org). The AARC's *Virtual Museum* can be accessed through the AARC website.

Oxygen Therapy

The therapeutic administration of oxygen first occurred in 1798; in 1878, Bert showed that lack of oxygen caused hyperventilation. However, the physiologic basis and indications for oxygen therapy were not well understood until the 20th century.[1,4] Large-scale production of oxygen was developed by von Linde in 1907. The use of a nasal catheter for oxygen administration was introduced by Lane in the same year.[1,4] Oxygen tents were in use in 1910, and an oxygen mask was used to treat combat gas–induced pulmonary edema in 1918.[1] In 1920, Hill developed an oxygen tent to treat leg ulcers, and in 1926, Barach introduced a sophisticated oxygen tent for clinical use. Oxygen chambers and whole oxygen rooms were designed.[1,4] In 1938, a meter mask was developed by Barach to administer dilute oxygen.[1,4] The BLB mask (named for Boothby, Lovelace, and Bulbulian) to administer 80% to 100% oxygen to pilots was introduced during World War II and later used for clinical care (Fig. 1.1).[1,4] By the 1940s, oxygen was widely prescribed in hospitals, although there was still no good way to measure blood oxygen levels routinely until the mid-1960s, with the introduction of the Clark electrode, followed by the clinical use of the ear oximeter in 1974 and the pulse oximeter in the 1980s.[1,4,5] The Campbell Ventimask—which allowed the administration of 24%, 28%, 35%, or 40% oxygen—was introduced in 1960, and modern versions of the nasal cannula, simple oxygen mask, partial rebreathing mask, and nonrebreathing mask were available by the late 1960s. Portable liquid oxygen systems for long-term oxygen therapy in the home were introduced in the 1970s, and the oxygen concentrator soon followed. Oxygen-conserving devices—including reservoir cannulas, demand pulse oxygen systems, and transtracheal oxygen catheters—were introduced in the 1980s.

Fig. 1.1 The BLB mask (Boothby, Lovelace, and Bulbulian) to administer 80% to 100% oxygen to pilots was introduced during World War II and later used on patients in the 1950s and 1960s.

The late 1990s saw further advances in home oxygen therapy equipment with the introduction of oxygen concentrators used in conjunction with a pressure booster to allow for the transfilling of small portable oxygen cylinders in the home (see Chapters 41, 42 and 57). Smaller, lightweight portable oxygen concentrators were also introduced. Both of these advances have greatly enhanced the ability of patients receiving long-term oxygen therapy to walk and to get outside their homes. Furthermore, the National Institutes of Health launched the

Long-Term Oxygen Treatment Trial (LOTT), a randomized controlled trial to explore the benefits of supplemental oxygen in patients with chronic obstructive pulmonary disease (COPD) and mild resting hypoxemia (SpO_2 89% to 93%) or with exercise desaturation.[10] In contrast to the case of COPD patients with severe hypoxemia (i.e., resting room air SpO_2 <89%) in whom supplemental oxygen prolongs survival, the findings of LOTT showed that supplemental oxygen did not offer benefit for 2-year mortality or all-cause hospitalization.

RULE OF THUMB In 1974, the designation *respiratory therapist* became standard, and the RT became the allied health professional primarily concerned with the assessment, diagnostic testing, treatment, education, and care of patients with deficiencies and abnormalities of the cardiopulmonary system.

Aerosol Medications

Aerosol therapy is defined as the administration of liquid or powdered aerosol particles by inhalation to achieve a desired therapeutic effect. Bland aerosols (sterile water, saline solutions) or solutions containing pharmacologically active drugs may be administered. In 1802, the use of inhaled *Datura* leaf fumes, which contain atropine, to treat asthma was described.[11] Early use of aerosol medications dates to 1910 when the first use of aerosolized epinephrine was reported. Later, other short-acting bronchodilators—such as isoproterenol (1940), isoetharine (1951), metaproterenol (1961), albuterol sulfate (1980), and levalbuterol (2000)—were introduced, primarily for the emergency treatment of acute asthma attacks.[11] In the late 1990s, long-acting bronchodilators, initially administered twice daily and more recently administered once daily, were introduced for the maintenance treatment of COPD. Oral and injectable steroids were first used in the treatment of asthma in the early 1950s, and the use of aerosolized steroids for the maintenance of patients with moderate to severe asthma began in the 1970s.[11] Newer medications continued to be developed for aerosol administration, including even longer-acting bronchodilators (once every 24 hours), mucolytics, antibiotics, antiinflammatory agents, and combination drugs such as long-acting bronchodilators and antiinflammatories delivered in a single inhalation. Along with newer respiratory drugs, newer delivery devices such as dry powder inhalers and innovative designs for small-volume nebulizers have been introduced.

Mechanical Ventilation

Mechanical ventilation involves the use of a mechanical device to provide ventilatory support for patients. In 1744, Fothergill advocated mouth-to-mouth resuscitation for drowning victims.[1,6] During the mid- to late- 1700s, there was a great deal of interest in resuscitation, and additional procedures for cardiopulmonary resuscitation were developed.[1,4,6] Positive-pressure ventilation using a bag-mask system or bellows was suggested. However, the observation that a fatal pneumothorax may result caused this technique to be rejected around 1827.[1,4] Interest in negative-pressure ventilation developed, and the first negative-pressure tank ventilator was described in 1832 (Fig. 1.2).[6] Other negative-pressure ventilators began to appear in the mid-1800s; in 1928, the iron lung was developed by Drinker, an industrial hygienist and faculty member at Harvard University.[1] Emerson developed a commercial version of the iron lung, which was used extensively during the polio epidemics of the 1930s and 1950s (Figs. 1.3–1.5).[1,12] The chest cuirass negative-pressure ventilator was introduced in the early 1900s (Fig. 1.6), and a negative-pressure "wrap" ventilator was introduced in the 1950s.[13] Other early noninvasive techniques to augment ventilation included the rocking bed (1950) and the Pneumobelt (1959).[13]

Originally, positive-pressure ventilators were developed for use during anesthesia; later, they were altered for use in hospital wards.[14] Early positive-pressure ventilators included the Drager Pulmotor (Fig. 1.7) (1911), the Spiropulsator (1934), the Bennett TV-2P (1948), the Morch Piston Ventilator (Fig. 1.8) (1952), and the Bird Mark 7 (1958) (Fig. 1.9).[1,14] More sophisticated positive-pressure volume ventilators were developed in the 1960s and included the Emerson Postoperative Ventilator, MA-1 (Fig. 1.10), Engstrom 300, and Ohio 560.[1,14] A new generation of volume ventilators appeared in the 1970s that included the Servo 900 (Fig. 1.11), Bourns Bear I and II, and MA-II. By the 1980s, microprocessor-controlled ventilators began to appear, led by the Bennett 7200 in 1984; in 1988, the Respironics bilevel positive-airway-pressure (BiPAP) device was introduced for providing noninvasive positive-pressure ventilation in a wide variety of settings.[1] During the 1990s and beyond, new ventilators have continued to be developed,

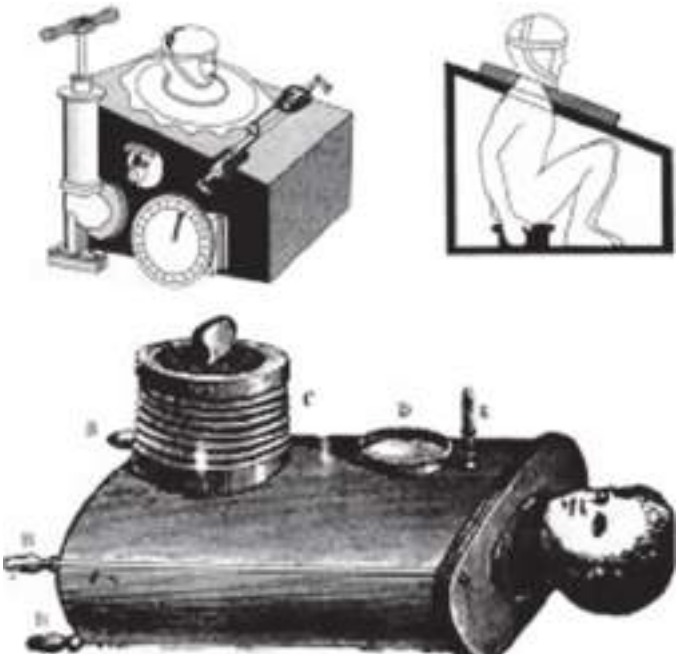

Fig. 1.2 Negative-Pressure Ventilator Used in the Mid-1800s. (*Top*, From Dalziel J: On sleep and apparatus for promoting artificial respiration. *BR Assoc Adv Sci* 1:127, 1838. *Bottom*, From Woollam CH: The development of apparatus for intermittent negative pressure respiration. (2) 1919–1976, with special reference to the development and uses of cuirass respirators. *Anaesthesia* 31[5]:666–685, 1976.)

Fig. 1.3 Multiperson Negative-Pressure Ventilation Chamber Used at Boston Children's Hospital. (From Public Health Image Library (PHIL), Centers for Disease Control and Prevention, Office of the Associate Director for Communications, Division of Public Affairs. CDC/GHO/Mary Hilpertshauser.)

Fig. 1.4 Iron Lung Patients in a 1950s Polio Ward. (From the Associated Press and Post-Gazette.com Health, Science and Environment. http://www.post-gazette.com/pg/05094/482468.stm.)

Fig. 1.5 Modern Negative-Pressure Ventilator Used in Europe. (From Albert RK, Spiro SG, Jett JR: *Clinical respiratory medicine*, ed 2, Philadelphia, 2004, Mosby.)

Fig. 1.6 Chest Cuirass Negative-Pressure Ventilator. (From Albert RK, Spiro SG, Jett JR: *Clinical respiratory medicine*, ed 2, Philadelphia, 2004, Mosby.)

Fig. 1.7 Drager Pulmotor, First Half of the 1900s. (From Mushin WW, Rendell-Baker L, Thompson PW, Mapleson WW: *Automatic ventilation of the lungs*, Oxford, 1980, Blackwell Scientific.)

including the Hamilton G5, Servo I, PB 840, (Fig. 1.12) and Drager V500 and VN500 series (see Chapter 46). Between 1970 and 2004, more than 50 new ventilators with various characteristics were introduced for clinical use.[15,16]

Early mechanical ventilators provided modes for which breaths were delivered according to a preset frequency and inspiratory time regardless of any inspiratory effort on the part of the patient (what anesthesiologists of the time called

Fig. 1.8 *Top left,* Morch ventilator; *bottom left,* Engstrom 300 ventilator; *right,* Emerson post-op ventilator. (From Mushin WW, Rendell-Baker L, Thompson PW, Mapleson WW: *Automatic ventilation of the lungs*, Oxford, 1980, Blackwell Scientific.)

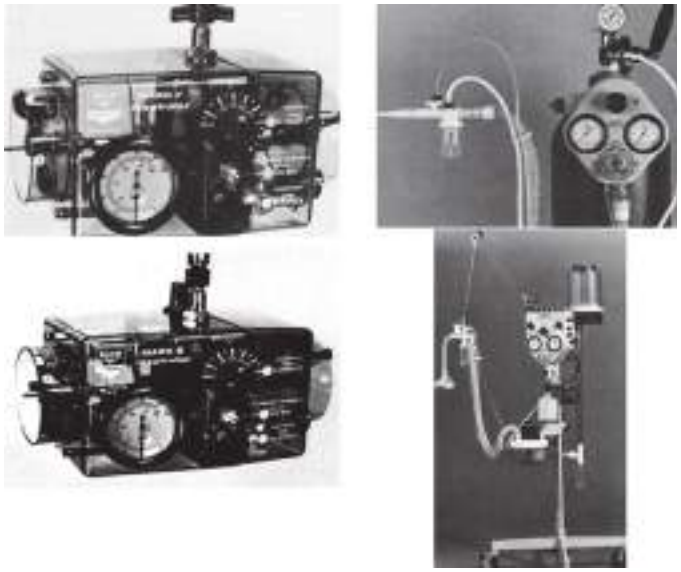

Fig. 1.9 *Top left,* Bird Mark 7 ventilator; *top right,* Puritan-Bennett TV-2P ventilator.; *bottom left*, Bird Mark 8 ventilator; *bottom right,* Puritan-Bennett PR-2 ventilator.

"controlled" ventilation). The early Bird and Bennett ventilators developed in the 1950s allowed for initiating inspiration by detecting the patient's inspiratory effort, called "assisted ventilation." This feature was incorporated in later modes that also had preset breath frequency (called *assist/control*, a term that is anachronistic but which persists to this day). The terminology related to modes of ventilation has evolved along with the complexity of ventilator technology (see Chapter 46). In 1967, the addition of positive end-expiratory pressure (PEEP) as a feature was introduced for use in patients dying from the newly described acute respiratory distress syndrome (ARDS). The use of PEEP helped to stabilize the alveoli and keep them from collapsing at the end of exhalation. Other forms of modern

Fig. 1.10 The Bennett MA-1 ventilator, introduced in 1967, played a major role in making mechanical ventilatory support routinely available in intensive care units throughout the world.

Fig. 1.11 Siemens Servo 900.

ventilation include intermittent mandatory ventilation (IMV), introduced in 1971, followed by synchronized IMV, in 1975, and mandatory minute volume ventilation in 1977.[1,4] Pressure-support ventilation and pressure-controlled ventilation were introduced in the 1980s, followed by airway pressure release

Fig. 1.12 *Left,* Covidien 840 ventilator; *middle,* Viaysis Avea ventilator; *right,* Siemens Servo I ventilator.

(APRV) ventilation and inverse ratio ventilation. In the 1990s, volume-support ventilation, pressure-regulated volume control (PRVC), and adaptive support ventilation (ASV) were introduced. Automatic tube compensation (ATC), proportional assist ventilation (PAV), neutrally adjusted ventilatory assist (NAVA), APRV, and other modes of ventilation were introduced around or shortly after 2000. In fact, there are now hundreds of names of modes of ventilation, making a classification system essential for understanding ventilator technology (see Chapter 46).

Because traditional short-term mechanical ventilation, regardless of mode, necessitates using an endotracheal tube, there is always the potential for one or more serious complications. The most common is an infection referred to as ventilator-associated pneumonia (VAP). VAP is a potentially deadly and very costly complication of invasive mechanical ventilation that develops when microorganisms accidentally enter the airway from the mouth and/or gastrointestinal (GI) tract. There has been a concerted effort to try to support the patient's inadequate ventilation and/or oxygenation by using non-invasive positive pressure ventilation or high-flow nasal cannula therapy in order to avoid the need for endotracheal intubation and the resultant risk of developing VAP.

Airway Management

Airway management involves the use of various techniques and devices to establish or maintain a functional airway. Tracheotomies may have been performed to relieve airway obstruction in 1500 BC.[6] Galen, the Greek anatomist, described a tracheotomy and laryngeal intubation in AD 160. Vesalius, another anatomist, described a tracheotomy in an animal in 1555.[1,6] In 1667, Hooke described a tracheotomy and the use of a bellows for ventilation.[6] In 1776, tracheal intubation was suggested for resuscitation.[6] In 1880, MacEwen reported successful oral endotracheal intubation in his patients.[6] O'Dwyer further described the technique for endotracheal tube placement. By 1887, Fell had developed a bellows–endotracheal tube system for mechanical ventilation, and this system was used in 1900 to deliver anesthesia.[6]

In 1913, the laryngoscope was introduced by Jackson. Additional early laryngoscopes were designed by Kirstein, Janeway, and others.[1,6] Endotracheal intubation for anesthesia administration was firmly established by World War I. After the war, Magill introduced the use of soft rubber endotracheal tubes, which made blind nasal intubation possible, as described by Magill in 1930.[6] In 1938, Haight advocated nasotracheal suctioning for secretion removal, and in 1941, Murphy described the ideal suction catheter, which included side holes known as "Murphy eyes."[6] The double-lumen Carlen tube for independent lung ventilation was introduced in 1940, followed by a double-lumen tube developed by Robertshaw in 1962. Damage to the trachea by the tube cuff was reduced with the introduction of low-pressure cuffs in the 1970s.[6]

> **RULE OF THUMB** Tracheotomies may have been performed to relieve airway obstruction as early as 1500 BC. Galen, the Greek anatomist, described a tracheotomy and laryngeal intubation in AD 160. Vesalius, another anatomist, described a tracheotomy in an animal in 1555.

Cardiopulmonary Diagnostics and Pulmonary Function Testing

Pulmonary function testing comprises a wide range of diagnostic procedures to measure and evaluate lung function. The volume of air that can be inhaled in a single deep breath was first measured in 1679, and the lung's residual volume (see Chapter 20) was first measured in 1800.[9] In 1846, Hutchinson developed a water seal spirometer, with which he measured the vital capacity of more than 2000 subjects.[9,17] Hutchinson observed the relationship between height and lung volume and that vital capacity decreases with age, obesity, and lung disease. Hering and Breuer described the effects of lung inflation and deflation on breathing—the Hering-Breuer reflex—in 1868.[4] In 1919, Strohl suggested the use of forced vital capacity (FVC), and in 1948, forced expiratory volume in 1 second (FEV_1) was suggested as a measure of obstructive lung disease by Tiffeneau.[9]

Arterial and venous oxygen and carbon dioxide contents were measured in 1837, and methods to measure blood oxygen

and carbon dioxide levels became available in the 1920s. These early methods for measuring blood oxygen, carbon dioxide, and pH were slow and cumbersome. In 1967, combination of the pH, Clark, and Severinghaus electrodes produced a rapid and practical blood gas analyzer for routine clinical use.[1,4] The ear oximeter was introduced in 1974, and the pulse oximeter was introduced in the 1980s. Sleep medicine became well established in the 1980s, and it was then that polysomnography became a routine clinical test, often performed by RTs.

PROFESSIONAL ORGANIZATIONS AND EVENTS

American Association for Respiratory Care

Founded in 1947 in Chicago, the Inhalational Therapy Association (ITA) was the first professional association for the field of respiratory care.[1,4,5] The purpose of the ITA was to provide for professional advancement, foster cooperation with physicians, and advance the knowledge of inhalation therapy through educational activities.[5] The ITA provided a forum to discuss the clinical application of oxygen therapy, improve patient care, and advance the art and science of the field.[1] The ITA had 59 charter members.[1] It became the American Association for Inhalation Therapists (AAIT) in 1954, the American Association for Respiratory Therapy (ARRT) in 1973, and the **American Association for Respiratory Care (AARC)** in 1982.[4,5] Today, the AARC has a formal affiliation with all 50 state respiratory societies (known as *chartered affiliates*), as well as with similar organizations in several foreign countries.[17]

RULE OF THUMB Founded in 1947 in Chicago, the ITA was the first professional association for the field of respiratory care. The ITA became the AAIT in 1954, the ARRT in 1973, and the **AARC** in 1982.

The stated mission of the AARC is to "encourage and promote professional excellence, advance the science and practice of respiratory care, and serve as an advocate for patients, their families, the public, the profession and the respiratory therapist."[19] The AARC serves as an advocate for the profession to legislative and regulatory bodies, the insurance industry, and the general public. To fulfill its mission, the AARC sponsors many continuing educational activities, including international meetings, conferences, and seminars (including virtual offerings during the pandemic), publications, and a sophisticated website (see www.AARC.org).[18] Finally, in an effort to ensure that the unique practice interests of AARC members are addressed (e.g., neonatal/pediatrics, adult acute care, management, home care, diagnostics), members are invited to join one or more of 10 Specialty Sections (Box 1.1) within the AARC designed to facilitate networking and the free exchange of ideas (see Chapter 2 for further details). Annually, the AARC also acknowledges individuals who have made sustained and substantial contributions to the profession as **Fellows of the American Association for Respiratory Care (FAARC)**.

RULE OF THUMB The stated mission of the AARC is to "encourage and promote professional excellence, advance the science and practice of respiratory care, and serve as an advocate for patients, their families, the public, the profession, and the respiratory therapist."

Many volunteers who have been elected to the AARC or House of Delegates leadership positions or have been asked to chair important committees started by volunteering at the

MINI CLINI

Preparing a Presentation for Respiratory Care Week

Problem

You are a staff therapist in a 300-bed hospital. Your supervisor asks you to prepare a 20-min presentation on the history and development of the respiratory care profession to be presented at the department's annual Respiratory Care Week luncheon. How would you gather the information needed and develop your presentation?

Solutions

First, review this chapter to get an overview of the history and development of the respiratory care profession. You may also want to read one or two of the supplemental references that are cited. Next, go to the AARC website (see www.AARC.org) and review the "Resources" and "Site Map" sections, which list many helpful resources. You should be able to find sections on "The History of the AARC," "Strategic Plan of the AARC," "Position Statements," and "White Papers." There will also be a portal to the AARC's Virtual Museum. You should also find a section on Respiratory Care Week. Review the material that the AARC has provided and develop an outline of your presentation. Your outline may include a brief overview of the history of science and medicine, the development of the respiratory care profession, and the future of respiratory care in the 21st century. Once you have your outline, decide on your delivery method. PowerPoint slides are easy to make and use. If you choose to do a PowerPoint presentation, a good rule of thumb is about one slide per minute, so you would need about 20 slides. Using your outline, begin to develop your presentation.

During the 1980s, the AARC began a major push to introduce state licensure for RTs based on the National Board for Respiratory Care (NBRC) credentials.[18] As of 2022, a total of 49 states, the District of Columbia, and Puerto Rico had state licensure or some other form of legal credentialing required for the practice of respiratory care. State licensing laws set the minimal educational requirements and the method of determining competence to practice. Competency is typically determined by obtaining a passing grade on a credentialing examination (administered by the NBRC) after graduation from an approved training program. State licensing boards also set the number of continuing education credits required to maintain active licensure.

BOX 1.1 American Association for Respiratory Care Specialty Sections

Adult acute care
Continuing care/rehabilitation
Diagnostics
Education
Home care
Long-term care
Management
Neonatal/pediatrics
Sleep
Surface and air transport

affiliate level. Student members of the AARC are always welcomed as volunteers, especially at the affiliate level. Student members of the AARC have access to a wide array of resources that can greatly enhance the experience of becoming a professional RT.

Respiratory Care Week

In November 1982, President Reagan signed a proclamation declaring the third week of each October as National Respiratory Care Week. Since then, Respiratory Care Week has become a yearly event to promote pulmonary health and the work of RTs in all care settings. RTs (and students) around the United States use Respiratory Care Week to celebrate their profession and dedication to high-quality patient care. Many respiratory care departments use the opportunity to conduct special events in their hospitals to help raise awareness of the vital role the RT plays as a member of the health care team. Other departments plan community activities to help the public understand the importance of good lung health and the role RTs play in diagnosing and treating breathing disorders. Respiratory Care Week is also an excellent opportunity for respiratory therapy students to become ambassadors of the profession to the rest of the student body. Some respiratory therapy classes conduct free breathing tests on campus, in shopping malls, or in community centers.

Board of Medical Advisors

Because RTs practice under medical direction, the AARC leadership receives formal input from physicians on all matters and questions pertaining to patient care. The **Board of Medical Advisors (BOMA)** is the group of physicians who provide this valuable input (see Chapter 2 for further details).

American Respiratory Care Foundation

Established in 1970 by the AARC, the **American Respiratory Care Foundation (ARCF)** is a not-for-profit charitable foundation that helps promote and further respiratory care. Commonly known as the Foundation, the ARCF collects and manages contributions from individuals, corporations, and other foundations to promote education among RTs (including scholarships for advanced training) and to recognize individual achievements of excellence in clinical practice, chronic disease management, public respiratory health, scientific research, and scholarship (see Chapter 2 for further details).

RULE OF THUMB Established in 1970 by the AARC, the **ARCF** is a not-for-profit charitable foundation that helps promote and further respiratory care.

International Council for Respiratory Care

The **International Council for Respiratory Care (ICRC)** is an AARC-sponsored organization dedicated to the globalization of high-quality respiratory care. As mentioned previously, having formally trained professionals working in a dedicated department to assume full responsibility for providing respiratory care under medical direction was unique to North America (i.e., both the United States and Canada). However, during the 1970s and 1980s, when many foreign physicians came to the United States to study, they became aware of what an RT was and the important role RTs play in hospitals nationwide. When these physicians returned to their native countries, they wished to have their own specialized teams able to provide the same level of high-quality respiratory care. However, because the health care delivery system is structured differently in each country, the specially trained teams were most often made up of nurses, physicians, or physical therapists, not RTs.

Formed in 1991, the ICRC (in close collaboration with the International Committee of the AARC) began to offer fellowships to interested foreign clinicians that provide the opportunity to visit the United States for 2 weeks before the annual International Respiratory Congress to observe how respiratory care is practiced in various settings. Pre-pandemic, the idea was to allow these international fellows to observe how the various components of respiratory care are practiced throughout the United States. The international fellows then took back to their home countries ideas and practices that could be integrated into their unique health care delivery systems. The program had been so successful that many countries (e.g., Mexico, Costa Rica, Taiwan) are starting to establish respiratory therapy training programs modeled after the American training system (see Chapter 2 for further details). The success of these programs suggests that they will resume full force once the pandemic subsides.

National Board for Respiratory Care

The credentialing body for registered RTs began in 1960 as the American Registry of Inhalation Therapists (to test and credential registered therapists), and a certification board was established in 1968 to certify technicians.[1,4] These two groups merged in 1974 as the National Board for Respiratory Therapy, which became the **National Board for Respiratory Care (NBRC)** in 1983.[1,4] Also in 1983, the National Board for Cardiopulmonary Technologists joined the NBRC, and the credentialing examinations for pulmonary function technology were brought in under the respiratory care umbrella.[1,4]

RULE OF THUMB For requirements for testing, examination schedules, study guides, and requirements for maintaining your CRT or RRT credential, check with the NBRC (see www.NBRC.org).

In 1998, the NBRC renamed the lower-level *certified respiratory therapist* (*CRT,* or *entry-level respiratory therapist*); the advanced level remained registered respiratory therapist (RRT, or advanced-level RT).[20] Until 2015, there were separate NBRC written exams for the CRT and the RRT credential. However, in 2015, the NBRC merged the two written exams into one known as "The Multiple Choice" or "TMC" exam, with a higher passing score (also known as "cut-score") for the RRT credential. While attaining the CRT credential only requires passing the TMC exam, the RRT credential continues to have

an additional credentialing exam requirement which is comprised of several clinical simulations. Not surprisingly, this second RRT credentialing exam is known as the Clinical Simulation Exam or simply the "CSE." It should be noted that as of the revision of this chapter for this edition of Egan's, it appears that effective 2027, the CSE credentialling exam will likely be eliminated and the TMC exam will be modified to reflect more critical thinking type questions, while retaining the cut-score distinction for earning the CRT or RRT credential.

In addition to the CRT and RRT, the NBRC began offering specialty examinations for pulmonary function technology in 1984 and neonatal/pediatrics in 1991. Because of the proliferation of new technologies, other specialty credentials including the Adult Critical Care Specialty (ACCS) and the Asthma Educator Certification (AC-E) have been introduced since then (see Chapter 2 for further details).

NATIONAL BOARD FOR RESPIRATORY CARE

Committee on Accreditation for Respiratory Care

In 1956, the first guidelines for respiratory care educational programs were published, followed in 1963 by the formation of the Board of Schools to accredit programs.[1] The Board of Schools was replaced by the Joint Review Committee for Inhalation Therapy Education (JRCITE) in 1970, led by Fred Helmholtz, its first chairman.[1,4] The JRCITE became the Joint Review Committee for Respiratory Therapy Education (JRCRTE) in 1977 and then the **Committee on Accreditation for Respiratory Care (CoARC)** in 1996 (see www.coarc.com).[4] Today, respiratory care educational programs in the United States and Canada are accredited by CoARC in collaboration with the Association of Specialized and Professional Accreditors (see Chapter 2 for further details).[21,22]

RESPIRATORY CARE EDUCATION

The first formal educational course in inhalation therapy was offered in Chicago in 1950.[1] In the 1960s, numerous schools were developed to prepare students to become RTs. Early programs concentrated on teaching students the proper application of oxygen therapy, oxygen delivery systems, humidifiers, and nebulizers and the use of various IPPB devices. The advent of sophisticated critical care ventilators, blood gas analyzers, and monitoring devices in the 1960s and 1970s helped propel the RT into the role of cardiopulmonary technology expert.

Respiratory care educational programs in the United States are offered at technical and community colleges, 4-year colleges, and universities. These programs are designed to prepare competent RTs to care for patients. The minimum degree required to become an RT has traditionally been an associate degree.[21] However, many associate degree graduates see great opportunity in pursuing their bachelor's degree and some even higher degrees—master's and doctorates. At present, there are approximately 443 degree programs in the United States, including 1 in Puerto Rico and 11 master's degree programs. In addition, there are several accredited respiratory care programs in Canada; and a handful in Mexico, South America, Japan, India, Taiwan, Qatar, and other countries.[23,24]

RULE OF THUMB Jobs in management, education, research, or advanced clinical practice normally require bachelor's- or graduate-level educational preparation.

The AARC completed a Delphi study and held two important Education Consensus Conferences in the early 1990s to assess the status of respiratory care education and recommend future direction for the field.[25–28] The first conference suggested that major trends affecting the field were advances in technology; demographic trends and the aging of the population; a need to provide better assessment, outcome evaluation, problem solving, and analytic skills; use of protocol-based care; and the need to increase the focus on patient education, prevention, and wellness, to include tobacco education and smoking cessation.[27] The conference concluded that the curriculum should encompass a broad scope of clinical practice, a significant arts and science component, emphasis on communication skills, and a minimum of an associate degree to enter practice. The second Educational Consensus Conference, held in the fall of 1993, focused on strategies to implement the recommendations made at the first conference.[28] Both conferences identified the need for more baccalaureate and graduate degree programs in respiratory care. The view that programs should prepare students better in the areas of patient assessment, care plan development, protocols, disease management, pulmonary rehabilitation, research, and geriatrics/gerontology became well accepted.[29,30]

The profession of respiratory care has been described as "a calling or vocation requiring specialized knowledge, methods, and skills as well as preparation, in an institution of higher learning, in the scholarly, scientific, and historical principles underlying such methods and skills."[31] The authors noted that professional roles are different and more complex than technical roles, which are oriented to performing specific tasks as ordered by the physician. Examples of professional roles in respiratory care include patient assessment and education, care plan development, ventilator management, disease management, pulmonary rehabilitation, and respiratory care consulting services. Technical roles may include basic task performance (e.g., oxygen, aerosol therapy, bronchial hygiene), routine diagnostic testing (e.g., electrocardiography, phlebotomy), and other routine tasks in which little or no assessment is required and decisions are limited to device selection and fine-tuning therapy.[31] In professional practice, the therapist may function as a physician extender who applies protocols or guidelines.[31] Examples include making protocol-based ventilator adjustments, applying assessment-based care plans, and performing advanced procedures such as arterial line insertion and management, intubation and extubation of patients, applying ventilator liberation or weaning protocols, and applying advanced cardiopulmonary technologies

(e.g., extracorporeal membrane oxygenation, nitric oxide therapy, aortic balloon pumps).

Notably, although economic, educational, and institutional forces may sometimes limit respiratory care in certain settings to a task-oriented, technical role,[31] there remain many opportunities for the RT to function as a physician extender, in a role similar to that of the **physician assistant.** Working under the supervision of a physician, the physician assistant may perform many medical procedures that might otherwise be performed by a physician. In a similar way, the respiratory physician extender such as pulmonologist assistant or anesthesiologist assistant offer the potential to improve the quality of care while controlling costs and minimizing unnecessary care. Many authorities believe that the critical thinking, assessment, problem-solving, and decision-making skills needed for advanced practice in the 21st century require advanced levels of education.[31]

In 1998, Hess[32] observed that a task orientation has coincided with a pattern of overordering and misallocation of respiratory care services. Therapist-driven protocols have helped address these concerns by shifting the role of the RT to more of a consultant, allowing him or her to assess the patient and then develop, modify, and implement a care plan once the physician has ordered the protocol.[32] Protocol-based care has been shown to be safe and effective while reducing misallocation of care and helping to control costs.[33,34] Acceptance by physicians of RTs in such consultative roles depends on the specific setting and importantly, on the professionalism, education, and skill of the RT at the bedside.[32]

In 2001, a report titled *Conference Proceedings on Evidence-Based Medicine in Respiratory Care* was published.[34] Evidence-based practice requires careful examination of the evidence for diagnosis, treatment, prognosis, and, in turn, practice using a formal set of rules.[35] The best evidence is used for clinical decision making, which should lead to optimal respiratory care.[35] Evidence-based practice has been advocated for all respiratory care delivered.

MINI CLINI

Educational Program Advisory Committee

Problem

You are asked to serve on your respiratory care educational program advisory committee. The committee wants to know how respiratory care education has developed and where it should be headed. You are appointed as a member of a subcommittee to research these issues. What should you do?

Solution

You may want to read the sections in this chapter that cover the history and development of respiratory care education to get an overview. You may wish to obtain copies of some of the reference materials that are cited. Items that may be helpful are the AARC Delphi Study,[26] reports of the AARC education consensus conferences,[27,28] and articles about the future of respiratory care.[30–33,37,38] You may wish to review the AARC strategic plan (see www.AARC.org) and AARC statements regarding respiratory care education and credentialing.[11] After reviewing these materials, you should be well prepared to discuss the future direction of your educational program.

In 2002, the AARC, NBRC, and CoARC published their *Tripartite Statements of Support* (since retired in December 2020) which suggested that all RTs seek and obtain the RRT credential.[36] Endorsement of advanced training in respiratory care persists, including efforts to create and expand formal education and credentialing of anesthesiologist assistants. An AARC white paper followed in 2003, which encouraged the continuing development of baccalaureate and graduate degree programs in respiratory care (see Chapter 2 for further details).[37]

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SUMMARY CHECKLIST

- RTs apply scientific principles to prevent, identify, and treat acute or chronic dysfunction of the cardiopulmonary system.
- Respiratory care includes the assessment, treatment, management, control, diagnostic evaluation, education, and care of patients with deficiencies and abnormalities of the cardiopulmonary system.
- The AARC is the professional association for the respiratory care profession in the United States, with tremendous impact on respiratory care world-wide.
- RTs work under the direction of a physician who is specially trained in pulmonary medicine, anesthesiology, or critical care medicine.
- The American Registry of Inhalation Therapists was founded in 1960.
- The NBRC, the credentialing board for RTs, was founded in 1974.
- The first Board of Schools was established in 1963.
- The CoARC now accredits respiratory care educational programs.
- As the physiologic basis for oxygen therapy became understood, use of oxygen to treat respiratory disease became established by the 1920s, and oxygen was used routinely in hospitals by the 1940s.
- Use of aerosolized medications for the treatment of asthma began in 1910, with numerous new drugs being developed in the 20th century and continuing up to the present.
- Mechanical ventilation was explored in the 1800s. In 1928, Drinker developed his iron lung; this was followed by the Emerson iron lung in the 1930s, which was used extensively during the polio epidemics of the 1940s and 1950s, and the modern critical care ventilator, which became available in the 1960s.
- The ITA was founded in 1947, becoming the AAIT in 1954, the AART in 1973, and the AARC in 1982.
- The AARC now has eight specialty sections to provide resources to members based on where they are employed and practice.
- The ARCF offers many scholarships and grants to respiratory therapy students and is promoting advanced training for RTs through scholarships, etc.
- Although originally found only in the United States and Canada, the practice of respiratory therapy is quickly expanding around the world.
- Respiratory Care Week is a yearly event to promote the profession and raise awareness of the importance of good lung health.
- Many authorities endorse obtaining a bachelor's degree as the minimum credential for respiratory care practice and advanced degrees for research or advisory roles in respiratory care.

MULTIMEDIA RESOURCES

Additional Resources

NBRC https://www.nbrc.org

2

The Profession of Respiratory Care

Brian K. Walsh

OUTLINE

CHAPTER OBJECTIVES

- Describe the roles and function of the American Association for Respiratory Care, National Board for Respiratory Care, and the Commission on Accreditation for Respiratory Care within the respiratory care profession.
- Describe how professional and medical organizations contribute to the development and quality of the medical profession.
- Discuss the scope of respiratory care practice.
- Identify the settings in which respiratory therapists practice.
- Describe the roles and responsibilities of the director, education coordinator, quality assurance coordinator, supervisors/lead therapist, clinical staff, researcher, and medical director.
- Discuss accreditation, credentialing, medical direction, and licensure aspects of the respiratory care profession.
- Identify the roles that each professional respiratory therapist must play in the future growth of the respiratory care profession.

KEY TERMS

accreditation
American Academy of Sleep Medicine
American Association for Respiratory Care
American Society of Anesthesiologist
American Thoracic Society
Association for the Advancement of Medical Instrumentation
Board of Directors
Board of Medical Advisors
Centers for Medicare and Medicaid Services
clinical staff
CoBGRTE group
credentialing
credentials
department director
educational coordinator
House of Delegates
International Council for Respiratory Care (ICRC)
licensure
medical director
misallocation
National Association for Medical Direction of Respiratory Care

National Board for Respiratory Care
quality assurance coordinator
researcher
Respiratory Care journal
scientist
scope of practice
Society of Critical Care Medicine
supervisors/lead therapists
The Joint Commission

INTRODUCTION

The profession of respiratory therapy was officially established in the United States in 1930s[1] and has grown to approximately 191,457 respiratory therapists (RTs).[2] In the early years, RTs were often referred to as "oxygen technicians" or "oxygen orderlies" because most of their activities involved moving compressed cylinders of oxygen and administering oxygen. Most of these hospital employees were trained on the job. In the late 1940s through early 1950s, short training programs began to appear. The profession of respiratory therapy has grown drastically from those humble days. With the growth of mechanical ventilation therapy and monitoring the side effects of general anesthesia following surgery, the first postoperative care and intensive care units were born. Visionary anesthesiologists and intensivists valued our profession and began to train and use our services as physician extenders to safely and effectively provide mechanical ventilation. Just like oxygen therapy was to the birth of our profession, the volume and complexity of the patients we serve, and the advancement of respiratory therapies have not only sustained the profession but have grown it. Currently, respiratory therapy is one of the fastest-growing healthcare professions. This chapter will provide an overview of the profession of respiratory therapy today.

SCOPE OF RESPIRATORY CARE PRACTICE TODAY

According to the American Association for Respiratory Care (AARC), "Respiratory Therapists are healthcare professionals whose responsibilities include patient assessment, disease management, diagnostic evaluation, management, education, rehabilitation and care of patients with deficiencies and abnormalities of the cardiopulmonary system. The scope of practice includes the application of technology and the use of protocols across all care sites including, but not limited to, the hospital, clinic, physician's office, rehabilitation facility, skilled nursing facility, and the patient's home."[3] These responsibilities are supported by education, research, and administration. In addition, RTs perform several diagnostic activities (Box 2.1). The focus of patient and family education activities is to promote knowledge and understanding of the disease process, medical therapy, and self-help. Public education activities focus on the promotion of cardiopulmonary wellness.[4]

We live in exciting times for the profession of respiratory therapy. The information age of the future will be replete with changes in the scope of our practice. The science of respiratory therapy will continue to expand at the same pace as medicine.[5] The scope of practice will continue to incorporate data-driven and evidence-based new technologies, new therapeutic approaches, and data management skills.

PRACTICE SETTINGS

RTs provide direct care that ensures people recover from a wide range of medical conditions. RTs get to know their patients and their families and have the gift of helping them through trying times. You will find RTs in a variety of settings from the confines of a climate-controlled hospital or medical office to the extreme temperature changes of interfacility transport (Box 2.2). There are several combinations of practice and patient populations from which an RT can choose to work.

RESPIRATORY THERAPY DEPARTMENT COMPOSITION

Providing respiratory therapy is a business, and over the years, the business of providing respiratory therapy has greatly evolved. Like all well-run health-related businesses, the goal is to provide excellent service to clients. Interestingly, RT departments serve several clients. RT department clients include the patients to which we provide respiratory therapy, the nursing units, and the physicians supported by the department. We often share responsibilities with monitoring, conducting tests, and providing care with the nurses and physicians with whom we work side by side.

Most RT departments are centralized, meaning they have centralized leadership, policies, procedures, medical direction, equipment, and staff. However, there are a few hospital systems that embrace a decentralized model. A decentralized model provides RT services as part of a service line with individualized leadership that may or may not be an RT. There are pros and cons to each model, but a discussion of these is outside the

BOX 2.1 Respiratory Therapist Diagnostic Scope of Practice Activities

Diagnostic activities include but are not limited to:
1. Obtaining and analyzing physiologic specimens
2. Interpreting physiologic data
3. Performing tests and studies of the cardiopulmonary system
4. Performing neurophysiologic studies
5. Performing sleep disorder studies

Therapy includes but is not limited to:
1. The application and monitoring of medical gases and environmental control systems
2. Mechanical ventilator management
3. Insertion and care of artificial airways
4. Bronchopulmonary hygiene
5. Administration of pharmacologic agents
6. Cardiopulmonary rehabilitation
7. Hemodynamic cardiovascular support
8. Sleep support

BOX 2.2 Practice Settings of Respiratory Therapist

- Hospitals: providing respiratory therapy and patient education to individuals suffering from asthma and other respiratory conditions.
- Providing lifesaving therapies:
  - Intensive care units: managing ventilators that keep the critically ill alive.
  - Emergency rooms: delivering lifesaving therapies.
  - Operating rooms or postoperative care units: working with anesthesiologists to monitor patients' breathing during or following surgery.
- Newborn and pediatric care units: helping with conditions ranging from premature birth to cystic fibrosis.
- In patients' homes: providing regular checkups and making sure people have the resources they need to keep them out of the hospital.
- Sleep laboratories: helping diagnose life-altering disorders like sleep apnea.
- Skilled nursing facilities and pulmonary rehabilitation programs: helping older people breathe easier and get more out of life.
- Outpatient specialty clinics or medical offices: conducting pulmonary function testing and providing patient education.
- Hospitals or medical offices: providing smoking cessation programs assisting those who want to kick the habit for good.
- Ground and air transport programs: rushing to rescue people in need of a higher level of care.
- Hospital, insurance companies, or medical offices: providing disease management helping devise care plans for patients with complex respiratory diseases.

scope of this chapter. Although there are different compositions of respiratory therapy departments, this section will explore the ideal department. Fig. 2.1 illustrates the typical organization chart for a department with a clinical ladder.

Department Director

The most important element for delivering quality respiratory care is department leadership. The primary leader of the respiratory therapy department is the RT in the role of **department director**. Although this position may have many different names—director, technical director, department chief, manager, etc.—regardless of term used, the department director must be a highly skilled RT, energetic, forward thinking, innovative individual whose primary role is the quality of respiratory therapy delivery through the continued development of the science and practice of the profession. For this section, we will refer to this individual as the department director. Department direction is often the responsibility of the manager or coordinator of a respiratory therapy department, who must ensure the equipment and the associated policies, procedures, guidelines, and protocols have sufficient quality to ensure the safety, health, and welfare of the patient.

Medical devices are regulated under the *Medical Device Amendment Act* of 1976,[6] which comes under the authority of the U.S. Food and Drug Administration (FDA). The FDA also regulates the drugs that are delivered by RTs. The purpose of the FDA is to establish safety and effectiveness standards and to ensure that these standards are met by equipment and pharmaceutical manufacturers.

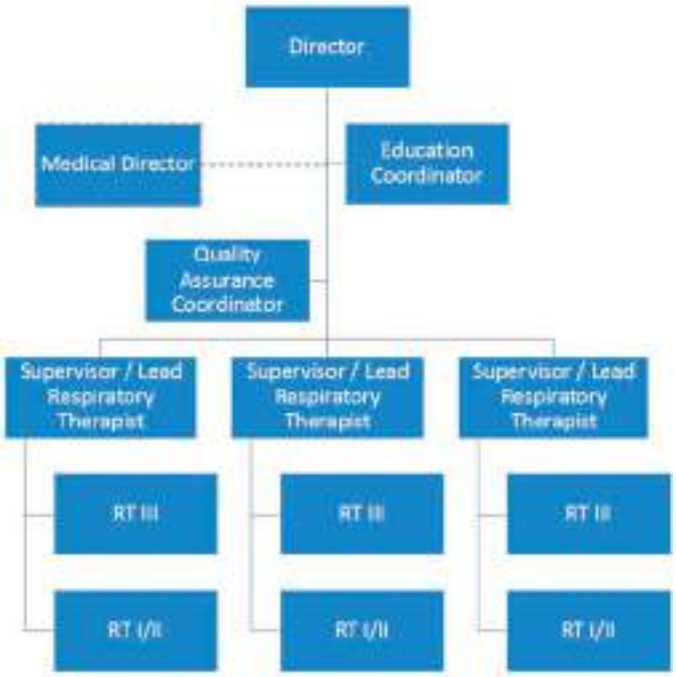

Fig. 2.1 Organizational Structure of a Typical Large Respiratory Therapy Department. *RT*, Respiratory therapist.

Procedures and protocols related to the use of equipment and medications must be written to provide a guide for the RT to follow. This ensures the consistency of the care provided. In addition, equipment must be safety checked and specific maintenance procedures must be performed on a regular basis. Because of rapidly changing respiratory care technology, the job of the Department Director poses significant challenges. Circuit boards and computers have replaced simpler mechanical devices. New medications and delivery devices for the treatment of asthma and newer strategies for treating other respiratory diseases (e.g., ventilatory approaches for acute respiratory distress syndrome [ARDS]) continue to evolve. Individuals responsible for department direction must ensure that these new devices, methods, and strategies are not only effective but also have value.

Educational Coordinator

The **educational coordinator** is tasked with individually assessing the educational needs of the RTs within the department and assigning resources to help reduce educational deficiencies. This includes the development and execution of orientation and continuing competency programs. In addition, this person is part of the leadership of the department and helps develop educational plans related to new technology being evaluated or instituted. In smaller departments, this role can be picked up by the director, manager, supervisors, or experienced RTs with an interest in education. This role is essential to ensure the coordination of education to improve quality and compliance with standards and policies and procedures.

Quality Assurance Coordinator

As the profession of respiratory care continues to move from a task and procedure-focused profession to the value associated

BOX 2.3 Change From the Volume to the Value Paradigm

- Traditional: Efficiency = RVU/FTE
- Value-based: Efficiency = Benefit/FTE

FTE, Full-time equivalents; *RVU,* relative value unit.

with those procedures, our quality metrics have changed and become more complex. The **Quality Assurance Coordinator** helps evaluate not only the efficiencies of the **clinical staff** but also the value associated with the practice of respiratory care. Traditionally, efficiencies were determined by the number of procedures (measured by relative value unit (RVU)/time standard) divided by the effort, largely measured by full-time equivalents (FTEs). This was easy to do, but to measure value, one must take into consideration things such as risk—benefit ratio or defined benefit, which can be more difficult (Box 2.3).

Value-based efficiency is determined by the amount of benefit provided by the therapy offered divided by the effort in FTEs. As you can imagine, benefit can be determined in cost savings, survival, or perceived benefit from the patient. Most value-based models use cost as the objective measure. Cost-efficient care is often viewed as higher-quality care.

In addition, as professionals, it is proper for us to determine the quality of care provided by evaluating the care we provide as well as the associated outcomes. This requires resources. As with the educational coordinator in smaller departments, this role can be picked up by the director, manager, supervisors, or experienced RTs with an interest in quality. This role is an integral part of a professional respiratory care department and identifies opportunities to improve the care provided and works hand in hand with other department leaders to develop appropriate action plans.

RULE OF THUMB High-quality care is always safe and efficient.

Researcher/Scientist

A role that has been growing over the years is the role of respiratory therapy **researcher or scientist** (see Chapter 8).

This role has been beneficial in the profession of nursing. As we switch to more value-based care, evidence of the benefit to our practice is paramount. Some department leaders have started to invest into their practice by employing scientists to help study new and old practices and technology in an effort to continuously improve the care the department provides. These individuals are expert clinicians and have advanced degrees in science. This role not only investigates the research questions of the department leaders but also helps the clinical staff in asking and solving their own questions about the care they provide.

Supervisors/Lead Therapists

Supervisors or **lead therapists** are roles that are defined by their names. They are often more experienced, are higher credentialed, and hold a higher level of education. These RTs help oversee and ensure the day-to-day functionality of the department by assigning clinical staff to appropriate workloads and areas in which the department provides services. The supervisor or lead therapist is also a clinical resource to assist with advanced procedures (low-volume, higher-risk), emergencies, and consults with difficult-to-treat patients. The supervisor is also the front-line leader for managerial issues such as personnel disputes or conflicts.

Respiratory Therapists

The heart of any respiratory therapy department is its front-line bedside staff. All other roles within the respiratory therapy departments are supportive to these individuals. The product of the department is largely provided by this role group. Most, if not all, clinical staff of the average department must be licensed (registration in Alaska) to provide respiratory therapy. This is a standard that is not negotiable, and it is in the best interest of our patients. Licensed RTs have met a minimum level of competency determined by the **National Board for Respiratory Care** (NBRC) **credentialing** system.

Clinical staff are deemed competent and provide the care outlined by the departments' policies, procedures, and standards of practice. They often work 12-hour shifts providing care to patients from the youngest (the neonates) to the oldest (the geriatric patients). In larger departments, they are often allowed to specialize and work in a specific area of the hospital. Clinical staff are first-line providers of respiratory care but also responders to rapid-response alerts, codes, and disaster/fire emergencies.

The largest personnel group and arguably the most important is the direct care RT. In addition to a competent and dedicated department director and using well-constructed respiratory care policies, procedures, guidelines, and protocols, it is important to have capable RTs able to provide high-quality respiratory care. The quality of RTs depends primarily on their training, education, experience, and professionalism. Training teaches students to perform tasks at a competent level, whereas clinical education provides students with the knowledge they can use in evaluating a situation for making appropriate decisions.[4] Both adequate training and clinical education are required to produce qualified RTs who can assess patients and apply respiratory care procedures. Box 2.4 describes the professional characteristics of an RT.

Medical Director

The profession of respiratory care is one of the few allied health professions that requires a medical director. The **medical director** of respiratory care is professionally responsible along with the department director for the quality of clinical care that is delivered (see Box 2.1). The medical director is also responsible for assisting and advising the department director on the management of the respiratory therapy department. Medical direction for respiratory care is usually provided by a pulmonary/critical care physician or an anesthesiologist. Whether the role of a respiratory care service medical director is designated as a full-time or part-time position, it is a full-time responsibility; the medical director must be available on a 24-hour basis to consult with and give advice to other physicians and the respiratory care

BOX 2.4 Professional Characteristics of a Respiratory Therapist

- Completes an accredited respiratory therapy program
- Obtains professional credentials
- Participates in continuing education activities
  - Adheres to the code of ethics put forth by the institution or state licensing board or both[a]
  - Joins and is actively involved in professional organizations

[a]Ethical standards include respecting the privacy of the patient's personal health information (see Chapters 5).

BOX 2.5 Responsibilities of a Medical Director of Respiratory Therapy

- Medical supervision of respiratory therapists in the following areas:
  - General medical, surgical, and respiratory nursing wards
  - Intensive care units
  - Ambulatory care (including rehabilitation)
  - Pulmonary function laboratory
- Approval of department clinical policies and procedures
- Supervision of ongoing quality assurance activities

staff. Box 2.5 describes the responsibilities of a medical director of respiratory therapy.

Perhaps the most important part of providing high-quality respiratory care is to ensure that the care being provided is clinically indicated, the procedure or protocol is based on the most current research, and it is delivered competently. Traditionally, a physician has evaluated patients for respiratory care and has written the specific respiratory therapy orders for the RT to follow. However, such traditional practices often have been associated with what has been called "**misallocation** of respiratory care."[7–9] Such misallocation may consist of ordering therapy that is not indicated, ordering therapy to be delivered by an inappropriate method, or failing to provide therapy that is clinically indicated. Studies show that misallocation of respiratory care occurs frequently and therefore requires focused attention by the department director and medical director to eliminate waste and add value to the care provided by the department.

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Scope of Practice

Problem: You are a staff therapist in a 300-bed hospital. You have been asked to assist a new physician with a bronchoscopy but are not sure the physician has the competency to safely complete the procedure. Additionally, you have not completed a competency for bronchoscopy assist. The physician assures you they are competent and can show you exactly what you should do. How should you investigate whether: (a) the physician is given privileges to perform, and (b) you should assist without proper training.

Solution: All hospitals should have a "look-up" reference listing the privileges extended to all healthcare providers. This is usually located within the intranet of the hospital. If you are concerned that you do not have the proper training, then you likely do not. You should call your resource or supervisor in an effort to locate a resource who can assist—not in an effort of denying support to a fellow colleague. If your supervisor cannot assist, escalate the concern to the director or medical director for assistance.

DESIGNATIONS AND CREDENTIALS OF RESPIRATORY THERAPISTS

The two levels of general practice credentialing in respiratory care are: (1) certified respiratory therapists (CRTs), and (2) registered respiratory therapists (RRTs). Students eligible to become CRTs and RRTs are trained and educated in Commission on Accreditation for Respiratory Care (CoARC)-accredited colleges and universities. After completion of an accredited respiratory care educational program, a graduate may become credentialed by taking the written entry-level examination called The Multiple Choice or TMC exam. The exam has one minimum passing score (cut scores) for CRT and a higher cut score that allows the candidate to be eligible to take the clinical simulation examination and become an RRT. Once candidates meet or exceed the higher cut score, they are eligible to take a second exam to determine if they meet the minimum level of competency to become an RRT. Students who complete a 2-year program graduate with an associate degree, and students who complete a 4-year program receive a baccalaureate degree. Some RTs go on to complete a graduate degree (e.g., master's or doctorate) with additional study in the areas of respiratory care, education, management, research, or health sciences. The further development of graduate education in respiratory care has been encouraged by the AARC, and several master's-level RT programs are currently available. Table 2.1 summarizes the distribution of credentialed RTs; organizations overseeing respiratory care education (e.g., CoARC) are reviewed later in this chapter.

RULE OF THUMB For testing requirements, examination schedules, study guides, and requirements for maintaining your **credentials**, check with the NBRC website (nbrc.org).

PROFESSIONAL RESPIRATORY CARE ORGANIZATIONS TODAY

A profession is often described by its advancing science, technology, and practice; continuous improvement in quality by active participation of its members; maintenance of minimal competency (in our case credentialing); and leadership, research,

TABLE 2.1 Distribution of Active Credentialed Practitioners

Credential Type	Population of Credentialed Practitioners
Certified respiratory therapist (CRT)	269,910
Registered respiratory therapist (RRT)	179,823
Certified pulmonary function technologist (CPFT)	14,468
Registered pulmonary function technologist (RPFT)	5,276
Neonatal/pediatric specialist (CRT-NPS or RRT-NPS)	17,219
Adult critical care specialist (RRT-ACCS)	5,196
Sleep disorders specialist (CRT-SDS or RRT-SDS)	983

Note: Based on the NBRC 2021 Examinations in Review. https://www.nbrc.org/wp-content/uploads/2022/01/2021-Exams-in-Review-Info-Sheet.pdf. An RT may hold more than one credential.

and innovation. Professionalism is a key attribute to which all RTs should aspire and that must guide respiratory care practice. *Webster's New Collegiate Dictionary* defines a *profession* as "a calling that requires specialized knowledge and often long and intensive academic preparation." A professional is characterized as an individual conforming to the technical and ethical standards of a profession. RTs demonstrate their professionalism by maintaining the highest practice standards, engaging in ongoing learning, conducting research to advance the quality of respiratory care, and participating in organized activities through professional societies such as the AARC and associated state societies. Therefore, it is important to be involved with your professional societies. Box 2.4 lists the professional characteristics of the RT. These characteristics are vitally important because the continued value and progress of the field depends critically on the professionalism of each practitioner.

American Association for Respiratory Care

The AARC is the leading national and international professional organization for RTs. Founded in 1947, the AARC is a not-for-profit professional association with a membership that consists largely of RTs but also includes physicians, nurses, physical therapists, paramedics, and researchers. The AARC serves a larger societal mission to advocate and enhance the professionalism of RTs.

RULE OF THUMB The AARC offers discounted memberships to students and early career RTs.

The art of respiratory care (updates, best practices, opinions, themed highlights, professionalism, humanitarian topics) is supported by the AARC through the online version of the professional magazine called the *AARC Times*. In addition, there are "News Now" feeds that you can get via email and multiple social media feeds. The science of respiratory care is supported by the AARC through peer-reviewed publications and journal conferences held by the ***Respiratory Care* journal**. *Respiratory Care* journal is composed of an editorial board and editor-in-chief who are scientific leaders within the profession.

The AARC has several standing and special committees to support the profession, as well as an executive office that works tirelessly to advance, advocate, and promote the profession of respiratory care. Funding for the operations of the AARC is derived from membership dues, advertisements, grants, and educational programs and conventions. The AARC offers active, student, associate, life, and honorary memberships. The AARC provides some of the highest membership benefits found in health-related professional organizations while maintaining some of the lowest dues. The AARC has multiple specialty sections with several having Board of Director seats to help represent all specialties.

RULE OF THUMB The AARC is the only professional association dedicated to promoting, advancing, and advocating for RTs.

Board of Directors

Governance of the AARC comes through the **Board of Directors** (BOD) in conjunction with the **House of Delegates** (HOD). The executive government of the AARC is composed of the BOD made up of no more than 18 active AARC members with at least five officers (six when there is a president-elect) and 12 directors-at-large, and section chairs serving as directors from each of the specialty sections having 1000 members or more. The AARC BOD members are selected by the membership of the organization. The Executive Director of the AARC serves as an advisor to the BOD and reports to the current President of the AARC.

House of Delegates

The HOD is a representative body for the chartered affiliate societies. This body is leveraged to help contribute to sustaining, governance, and future growth of the profession through grassroots efforts. The HOD is a vehicle in which the general membership can bring issues or concerns from the local society to the national organization. The HOD is a conduit of information, reporting activities, data, and information to the local level. HOD membership is composed of one to three members from the chartered affiliates. Currently, there are 50 delegations representing 48 states. Vermont and New Hampshire, and Maryland and the District of Columbia have combined resources to make up one delegation each. The territory of Puerto Rico has its own delegation. The HOD elects officers from its delegation. The officers are Speaker-Elect, Speaker, Immediate Past Speaker, and Treasurer/Secretary.

Board of Medical Advisors

The **Board of Medical Advisors** (BOMA) also helps assist the AARC with the governance of practice-related issues and consists of representatives of the AARC's sponsoring organizations: the **American Thoracic Society** (ATS), the American College of Chest Physicians (ACCP), American Academy of Pediatrics (AAP), the American College of Allergy, Asthma, and Immunology (ACAAI), the National Association for Medical Direction of Respiratory Care (NAMDRC), **Society of Critical Care Medicine** (SCCM), and the **American Society of Anesthesiologists (ASA)**. BOMA consist of no fewer than 12 members nominated from each sponsoring society. The BOMA chair serves on the AARC BOD, and the chair rotates so that each society will have a representative serve on the BOD.

President's Council

The President's Council is an advisory body composed of past presidents of the AARC. The council has significant experience and wisdom through their activities at the highest position within the AARC. The chair is elected by the members of the President's Council and serves in an advisory position to the BOD.

National Board for Respiratory Care

The NBRC is a voluntary credentialing agency founded in 1960. The NBRC's mission is to promote excellence in respiratory care by awarding credentials based on high competency standards while sharing the profession's goal of protecting and enhancing patient lives.[10] The NBRC has established standards for the credentialing of RTs who work under medical direction and in cooperation with agencies setting educational standards and licensing agencies who provide licensing of RTs. These high standards have been recognized nationally and are the standard

for licensure in 49 states. The NBRC publishes an electronic newsletter called NBRC Horizons and provides a directory of credentialed individuals. In 2021, the NBRC administered 22,443 examinations totaling 492,875.[11]

National Board for Respiratory Care Examinations

Table 2.1 provides an overview of the different professional credentials awarded by the NBRC with an approximate number of practicing individuals with those credentials. The NBRC examinations are graded with a minimum pass level preestablished by the examination committee using a modified Angoff procedure. This accepted psychometric procedure uses the judgements of content experts to determine the number of correct answers required to achieve a passing score for the examinations. The NBRC is governed by a 31-member Board of Trustees composed of representatives from four sponsoring organizations; the AARC, ACCP, ASA, and ATS.[10] A Public Advisor is elected by the board to provide a consumer perspective.

The National Asthma Educator Certification Board (NAECB) was established in 2000 to develop and implement qualification/standards, as well as a certification examination for asthma educators on a national level. Recently, the NBRC acquired NAECB and are in the process of joining forces. The AE-C—credentialed individual is an expert in teaching, educating, and counseling individuals with asthma and their families in the knowledge and skills necessary to minimize the impact of asthma on their quality of life. RTs make ideal asthma educators because they are very knowledgeable on the optimal uses of medications and delivery devices.[12]

Commission on Accreditation for Respiratory Care

Professional accreditation of educational programs in respiratory care assures prospective students, their families, and the general public that the institution meets the minimum professional educational standards for the degree they are offering and there is reasonable evidence that they will continue to meet those standards in the future. The CoARC was founded in 1954 to accredit respiratory care degree programs at the associate, baccalaureate, and master's degree level in the United States and Puerto Rico.

As of December 31, 2021, there were a total of 447 accredited programs. There were 413 Entry into Respiratory Care Professional Practice, 6 Sleep Specialist programs, and 29 Degree Advancement (DA) programs and 1 Advanced Practice Respiratory Therapist program. Eighty-two percent of the entry-to-practice programs were at the associate degree, 17% at the baccalaureate degree, and 1% offered at the master's degree level. There has been a 35% decrease in AS programs since 2015.[13]

RULE OF THUMB CoARC is the accrediting body of respiratory therapy educational programs. CoARC-accredited programs meet the minimum professional educational standards.

American Respiratory Care Foundation

The American Respiratory Care Foundation (ARCF) is dedicated to promoting respiratory health through the support of research, education, and patient-focused philanthropic activities in respiratory care. The ARCF Board of Trustees is composed of respiratory professionals, including emeritus trustees who conduct the business and manage the decisions of the ARCF.

The ARCF supports the Respiratory Care Journal Conferences, which are conferences designed to be evidence-based and timely and provide important information affecting the practice of respiratory care everywhere. These conferences are limited to the faculty and staff of the journal. Each topic is thoroughly presented by an invited expert, followed by heavy discussion among the faculty. The state-of-the-art proceedings appear in a special issue of Respiratory Care both in print and online.

As a part of their mission, the ARCF also provides and maintains three Undergraduate Student Awards, four Fellowship Awards, three Research Grants, seven Achievement Awards, and two Literary Awards and heavily supports the International Fellowship program. These grants, awards, and recognitions are the output of fundraising. The ACRF could not support research, education, and charitable activities to help improve the quality of our environment if it were not for the generosity of others.[14] The ARCF holds annual fundraising events to ensure the success of the foundation. The AARC supports the ARCF with administrative assistance.

Coalition for Baccalaureate and Graduate Respiratory Therapy Education

The Coalition for Baccalaureate and Graduate Respiratory Therapy Education (CoBGRTE) is organized to help students, faculty members, and the general public learn about baccalaureate and graduate respiratory therapy education in the United States.

The objectives of CoBGRTE are to:

- Award scholarships to baccalaureate and graduate respiratory therapy students.
- Maintain a current roster of baccalaureate and graduate respiratory therapy programs located in regionally accredited colleges or universities in the United States.
- Provide a means of communication among respiratory therapy educators.
- Assist faculty members that are developing curricula for new baccalaureate and graduate respiratory therapy programs.
- Conduct research on respiratory therapy educational programs and the healthcare workforce.
- Engage in study and planning related to the development of new baccalaureate and graduate respiratory therapy programs.
- Assist associate degree respiratory therapy programs in developing consortium and transfer agreements with colleges offering baccalaureate and graduate degrees.
- Advocate for development and establishment of baccalaureate and graduate respiratory therapy programs.

The CoBGRTE BOD consists of 19 professionals in various positions within respiratory therapy. CoBGRTE awards eight merit scholarships and one research scholarship annually and publishes The Coalition Chronicle. The Chronicle helps to highlight programs and best practices of educational institutions. Currently, there are 69 institutional members that finically support CoBGRTE.[15]